Power-based multi-cell call admission control scheme for wideband-CDMA systems

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ABSTRACT

Wideband code division multiple access (WCDMA) systems are interference-limited. When a WCDMA system operates at nearly full capacity, admitting a new user may affect the stability of the system. Therefore, the proper call admission control (CAC) is crucial and should balance between quality of service (QoS) requirements for the new user as well as for the existing users and the required high capacity. In this paper, we investigate this trade-off in the uplink direction using a power-based multi-cell admission control (MC-AC) algorithm. Multimedia services are considered with different QoS requirements in this algorithm. Different traffic scenarios are also considered. Simulation results reveal that the proposed MC-AC algorithm has many advantages over single-cell admission control (SC-AC) in terms of the overall stability of the system and the total system throughput.

1. Introduction

The WCDMA technology has been established as the main air interface for the third generation (3G) mobile systems. Any WCDMA system is an interference-limited system, where each signal transmitted in the air interface is seen by the desired signal as a wideband noise. Admitting too many users leads to degradation in the QoS for the new user and the ongoing connections as well. Therefore, admission control plays a very important role in providing the user with the required QoS as well as making an efficient use of the available capacity and preventing the system from an outage situation due to overloading.

An ideal CAC mechanism should accept a call if and only if the power control algorithm is able to reach a new equilibrium state with a guaranteed good quality for all connections. The interactive CAC scheme is very close to the ideal CAC scheme because it allows the new connection to transmit for a trial period during which it takes measurements to determine whether the connection can be tolerated or not [1,2]. Unfortunately, these schemes are not practical due to the long time consumed to make measurements and make a decision. In the uplink, the received power at the base station is considered the best parameter that reflects the current load in the network. In [3], a simple received power-based admission control scheme was proposed. The measured interference includes both intra-cell and inter-cell interference and the measured values are compared with a threshold. The new call attempt is only accepted if the threshold is not exceeded. The acceptance threshold must be carefully tuned to limit the dropping probability.

A CAC algorithm using multiple power-based thresholds for multiple services was proposed in [4]. In [5,6], a predictive received power-based CAC algorithm has been proposed to reduce the safety margin of the admission threshold by estimat-
ing the additional interference due to the new call. In [5], an uplink admission control strategy based on the received wideband interference is introduced. In [6], a multi-cell estimation scheme for increments in power was proposed. This scheme tries to improve the performance of the system by estimating the power increment due to the new user in the serving cell and also in the neighboring cells. In [7,8], both analytical and simulation models are presented to evaluate the MC-AC algorithm with different traffic scenarios when elastic services, that accept degradation, are considered.

In this paper, we propose a model to investigate the performance of the received power-based MC-AC algorithm when multimedia traffic is considered with different QoS requirements. The trade-off between the class-wise blocking and dropping probabilities is studied. Fast power control is used with admission control after a new user is admitted to bring the system to a new equilibrium state, in which each user tries to reach its target signal-to-interference ratio.

The rest of the paper is organized as follows. Section 2 introduces the system model and the theoretical assessments that are required to build the simulation environment. Section 3 presents the proposed MC-AC algorithm. The concepts of the load factor and the noise rise and the relation between them, that represents the basis for the admission control criteria, are also described. The simulation model is described in Section 4. The simulation results and the discussions are presented in Section 5. Finally, the concluding remarks are given in Section 6.

2. System model

Consider the uplink in a WCDMA cellular radio system with C cells and K service classes. Let $M_k$ denotes the number of active mobile stations of class $k$ in the system. The total received power at the base station of cell $c$ can be represented as:

$$ P_{\text{tot},c} = P_{\text{own},c} + P_{\text{oth},c} + P_N $$

where $P_{\text{own},c}$, $P_{\text{oth},c}$ represent the received power from the mobile stations in the home cell and the neighboring cells, respectively, and $P_N$ is the background noise power.

Let us define $P_{ij}$ as the coupling factor between the user $i$ that belongs to cell $j$ and the cell $c$. It is given by the ratio of the path gain between the user $i$ and the neighboring cell $c$ ($h_{ic}$), and the path gain to its home cell $j$ ($h_{ij}$).

$$ P_{ij} = \frac{h_{ic}}{h_{ij}} $$

From the above definitions, it follows that:

$$ P_{\text{own},c} = \sum_{k=1}^{K} \sum_{i=1}^{M_k} P_{\text{tx},k,ij} h_{ic} $$

$$ P_{\text{oth},c} = \sum_{j=1}^{C} \sum_{k=1}^{K} \sum_{i=1}^{M_k} P_{\text{tx},k,ij} h_{ij} P_{ij} $$

where $M_k$ represents the number of active users of class $k$ in the cell $c$, $P_{\text{tx},k,ij}$ is the transmitted power of user $i$ of class $k$ that belongs to cell $c$.

Each service class is characterized by a required bit rate. When a user of class $k$ is transmitting at rate $R_k$, the required target ratio of the received power from the mobile terminal to the total interference is defined as:

$$ \gamma_k = \frac{(E_b/N_0)_k}{W/R_k} $$

where $(E_b/N_0)_k$ is the energy per user bit, $E_b$, divided by the noise power density, $N_0$, for class $k$. This value should meet the QoS requirements in terms of the bit error rate (BER) taken from the link level measurements. $W$ is the chip rate.

Our objective is to find the required received power at the base station from a user of class $k$ in order to achieve the predefined target signal to noise and interference ratio and to express this power as a load increment in the system. The power received at the base station of cell $c$ from a user $i$ of class $k$, $P_{\text{tx},k,ci}$, has to fulfill the following condition:

$$ \frac{P_{\text{tx},k,ci}}{P_{\text{tot},c} - P_{\text{tx},k,ci}} = \gamma_k $$

The objective of power control in the uplink is to keep the transmitted power of the mobile station at a level that satisfies Eq. (6). Assuming equal received power for all the active users of class $k$ (perfect power control), the required received power of the mobile station $i$ of class $k$ can be obtained from Eqs. (5) and (6) as follows:

$$ P_{\text{tx},k,ci} = \frac{(P_{\text{oth},c} + P_N)(E_b/N_0)_k}{(W/R_k) - (M_k - 1)(E_b/N_0)_k} $$

Note that all the parameters in Eq. (7) are known. $P_{\text{oth},c}$ can be measured at the base station and $M_k$ is the number of active mobile stations of class $k$ including the new one. Then, the required initial transmitted power for the new arrival $i$ of class $k$ is estimated as:
\[ P_{x,k,c,i} = \frac{P_{x,k,c,i}}{h_{i,c}} \]  

Eq. (8) is used to allocate the initial transmitted power for the user before the power control algorithm is executed.

3. Power-based multi-cell admission control

In this section, the proposed power-based multi-cell admission control algorithm is presented. The power increment due to the possible admission of the new user is estimated and this power increment is expressed as an increment of the load factor of the system which is defined in the following subsection.

3.1. Load factor and noise rise

The admission control algorithm estimates the increase in the total received power due to a new user and decides to accept or reject this user according to the current system state. Solving for \( P_{x,k,c,i} \) in Eq. (6) gives:

\[ P_{x,k,c,i} = \frac{\gamma_k}{1 + \gamma_k} \]

If we define \( P_{x,k,c} = \Delta \eta_k P_{\text{tot},c} \) as in [10], then

\[ \Delta \eta_k = \frac{P_{x,k,c}}{P_{\text{tot},c}} = \frac{\gamma_k}{\gamma_k + 1} \]

Note that \( \Delta \eta_k \) can be interpreted as the fraction of the system load that is generated by a user of class \( k \). Another way for expressing the total received power is to describe it as a rise over thermal noise (noise rise). The noise rise is defined as the ratio between the total received power at the base station and the thermal noise and is given by:

\[ A_c = \frac{P_{\text{tot},c}}{P_N} = \frac{P_{\text{own},c} + P_{\text{oth},c} + P_N}{P_N} \]

where \( P_N \) is the background noise. The last equation forms the basis for the admission control decision, since it has a direct relation with the total received power at the base station and the thermal noise and is given by:

\[ \eta_c = \frac{P_{\text{own},c} + P_{\text{oth},c}}{P_{\text{own},c} + P_{\text{oth},c} + P_N} = 1 - \frac{P_N}{P_{\text{tot},c}} \]

From Eqs. (11) and (12), the relation between the load factor and the noise rise is defined as:

\[ A_c = \frac{1}{1 - \eta_c} \]

Recall that the noise rise is the best indicator of the load level at the base station. So, it is usually taken as an admission decision parameter.

3.2. Admission control criteria

From the previous section, we know that Eq. (11) represents the basis for the admission control decision. A new user is admitted if the following condition is achieved:

\[ A_{\text{own}} < A_{\text{th}} \]

where \( A_{\text{own}} \) is the noise rise at the home cell after the new user has been admitted and \( A_{\text{th}} \) is the noise rise threshold. The noise rise threshold is a system parameter that is determined during the network dimensioning. Since it is impossible to exactly predict the noise rise increment before admitting the new user [6], the admission condition in Eq. (14) can be modified to:

\[ A_{\text{own}}^{\text{est}} < A_{\text{th}} - A_{\text{hr}} = A_{\text{tgt}} \]

where \( A_{\text{own}}^{\text{est}} \) is the estimation of \( A_{\text{own}} \) and \( A_{\text{hr}} \) is headroom parameter set as a safety margin to compensate for the estimation errors. Clearly, \( A_{\text{tgt}} < A_{\text{th}} \) and \( A_{\text{hr}} \) is considered a simulation parameter as will be seen in the simulation section. Eq. (15) can be extended to MC-AC as follows:

\[ A_{\text{est}}^j + A_{\text{hr}} < A_{\text{th}} \quad \forall j = 1, 2, \ldots, C \]

where \( A_{\text{est}}^j \) is the estimated noise rise for cell \( j \), and \( C \) is the total number of cells. The estimated noise rise for cell \( c \) is given by:
\[ A_c^e = \frac{P_{tot,c} + \Delta P_{est}^{k,c}}{P_N} \]  

\( \Delta P_{est}^{k,c} \) is the estimation of the single-cell power increment given as [5]:

\[ \Delta P_{est}^{k,c} = \frac{P_{tot,c} \Delta \eta_{c}^{ext}}{1 - \eta_c - \Delta \eta_{c}^{ext}} \]  

\( \Delta \eta_{c}^{ext} \) is the estimation of the load increment due to a possible admission of a new user of class \( k \) and is given by:

\[ \Delta \eta_{c}^{ext} = w \Delta \eta_{c}^{ext,k} + (1 - w) \Delta \eta_{c}^{ext,u} \]  

where \( \Delta \eta_{c}^{ext,k} \) is an overestimation of the load increment because it assumes that the power received from the other cells exactly increases by the same fraction as the own cell power. \( \Delta \eta_{c}^{ext,u} \) is an underestimation of the load increment because it assumes no rise in the other cell interference after the admission, and \( w \) is a weight parameter. From Eqs. (5) and (10), we get:

\[ \Delta \eta_{c}^{ext,k} = \frac{1}{1 + \frac{W_{N}R_{k}}{(k,R_{N})}} \]  

\[ \Delta \eta_{c}^{ext,u} = \frac{\eta_{c}^{ext,k} P_{N}}{P_N + P_{oth,k}} \]  

The power increment in a neighboring cell \( j \) due to admitting a user \( i \) of class \( k \) in the cell \( c \) is given by [6]:

\[ \Delta P_{est}^{k,j} = \frac{\eta_{c}^{ext,k}}{\eta_{c}^{ext}} \frac{h_{i,j}}{h_{i,c}} \]  

It should be noted that, in practical WCDMA systems, the path gain parameters can be obtained from the pilot reports that are sent from the mobile station to the nearest cells and measured at the base station. These reports provide information about the downlink path gain. However, since the uplink and downlink path gains only differ because of fast fading, the uplink path gain can be obtained.

4. Simulation model

To evaluate the performance of the CAC schemes considered in the previous section, we have built a simulation environment using Matlab. The main concern of the simulator is to compare between the performance of the SC-AC scheme and the proposed MC-AC scheme at different load distributions and different service classes.

4.1. Network topology

The topology of the system under consideration consists of seven cells; each with an inner radius of 850 m. The cell radius is chosen so that the user located at the cell edge will transmit at maximum power when full load is reached at the cell according to the calculations of the link budget parameters determined during the network planning phase. Each cell is served by one base station located at its centre and uses an omni-directional antenna with unity gain. In order to avoid the border effects, a compensation for the other cell interference is added in the simulation to the cells in the first tier; in both homogenous and heterogeneous load types such that the other-to-own cell interference in the surrounding cells is equal to that of the central cell.

4.2. Propagation model

The propagation model is characterized by an extensive set of channel quantities that reflects the propagation model. This set comprises the attenuation values. The radio attenuation comprises the path loss and the lognormal shadowing. We have adopted the propagation model described in [9,11] as follows:

\[ \text{Attenuation} = [128.1 + 37.6 \log(r)] + \zeta \text{ [dB]} \]  

where, \( r \) (Km) is the distance between the mobile station and the base station, \( \zeta \) (dB) has a normal distribution with zero-mean. It represents the effect of shadow fading. Furthermore, we assume that the shadowing standard deviation \( \sigma \) is equal to 8 dB. A user arriving at the system will choose its serving cell so that the radio propagation attenuation between the mobile station and the base station of its serving cell is minimized. The model is static, i.e. the users do not move. User mobility is not considered in the simulations in order to better verify the impact of admitted calls on the system, by decreasing the load variations resulting from the movement of users from cell to cell. As described in Section 2, the path gain is a fundamental parameter because it is the basis to calculate the coupling factor. Recall that it is the inverse of the attenuation defined in Eq. (23).
4.3. Power control model

The system under consideration is interference and power limited in the uplink, i.e. each mobile station has a maximum transmission power. The transmitted power is adjusted at each iteration to maintain the target signal-to-interference ratio $SIR_{k,tgt}$ for class $k$. The new power control level is adapted every 10 ms and the new power level for a user of class $k$ is evaluated as [11]

$$P_{tx,k,new} = P_{tx,k,old} \frac{SIR_{k,tgt}}{SIR_{k,cur}} \quad (24)$$

where, $SIR_{k,cur}$ is the current SIR experienced by the mobile station of class $k$. If the power control requires a power level higher than the maximum value, the maximum value is adopted. After each power control iteration, the actual SIR values experienced by each user are evaluated. If the SIR is lower than the required $SIR_{k,req}$ for class $k$, the call is considered in an outage situation. The call is dropped if three consecutive frames suffer from outage. In our simulations, the target value is taken to be greater than the required value by 1 dB to compensate for power control errors [11,12].

4.4. Traffic model

In WCDMA systems, there are real-time services and non-real time services. If the system has limited capacity, non-real time services can be served in the absence of real-time services. When real-time services are required, non-real time services may be delayed to create enough capacity for the real-time services. For our purpose, to evaluate the performance of the proposed MC-AC scheme, the system should operate at maximum capacity or near the threshold values. Thus, non-real time services are ignored in the proposed CAC scheme. We assume three real-time service classes; high data rate, low data rate, and voice services. These service classes need data rates of 128 Kbps, 64 Kbps, and 12.4 Kbps, respectively [13]. The $E_b/N_0$ values for the desired BER of the various services are given in Table 1 [10].

The initial call arrival process to a cell $c$ is modeled as an independent Poisson process with mean arrival rate $\lambda_c$. The call duration is modeled as an exponentially-distributed random variable. Two types of traffic distributions are considered in the simulation:

- **Homogeneous load**: The users are born with equal probability in all cells.
- **Heterogeneous (hot around) load**: The load in the central cell is 50% of the load in any of the surrounding cells.

The performance measurements of the system that are used in the simulation include the following:

- **Blocking probability**: Probability of a new call being blocked.
- **Dropping probability**: Probability that an ongoing connection cannot maintain its required $SIR_{req}$, which is defined in Eq. (5), and eventually dropped.
- **Mean system throughput**: The average number of bits successfully transmitted per second.
- **False accept probability**: Probability that the accepted user in the home cell will make the load in one or more of the surrounding cells violate the noise rise threshold and affect the stability of the system.

We have built a discrete-event simulator. One of the central functions of the discrete-event simulator is the simulation executive. The executive manages the time steps. In general, there are two basic approaches for controlling the time steps:

- **Time slicing (time-driven).**
- **Next event (event-driven).**

In the event-driven approach, the clock is updated by going from one event (e.g. arrival, departure, etc.) to the next one. On the other hand, in the time-driven approach, the simulation time is advanced at a fixed time-interval. Our simulations follow the time-driven approach with a time step that corresponds to the transmission of one time slot. In WCDMA systems, one frame of 10 ms comprises 15 time slots; each of duration 0.67 ms. In this period, all the events of the system such as new user arrival or user departure are checked. Fig. 1 shows the main steps performed in the simulation. Table 2 summarizes the input parameters that are used in the simulations.

<table>
<thead>
<tr>
<th>Service</th>
<th>Average bit rate (Kbps)</th>
<th>Required $E_b/N_0$ (dB)</th>
<th>Outage SIR Threshold (dB)</th>
<th>Service example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>12.4</td>
<td>5</td>
<td>−19.9</td>
<td>Voice</td>
</tr>
<tr>
<td>Class 2</td>
<td>64</td>
<td>4</td>
<td>−13.7</td>
<td>Medium multimedia, movie, music</td>
</tr>
<tr>
<td>Class 3</td>
<td>128</td>
<td>3.2</td>
<td>−11.57</td>
<td>Video conversation</td>
</tr>
</tbody>
</table>
Input all program parameters

Generate a cell layout and mobile distribution

Start main simulation loop:
- Offered traffic;
- Timenow=0; Set Timeend

Terminate some calls due to hang up

New user arrival?
Yes

No

Admission control

Single-cell

Check

$\eta + \Delta \eta < \eta_0$ ?

Reject user

Accept

No

For all cells?

Reject user

Inner loop power control in every frame (10ms)

Calculate FER

Congestion Control (drop some users)

Timenow < Timeend

Yes

Calculate FER

Congestion Control (drop some users)

Timenow = Timenow + $\Delta t$

Yes

Collect statistics

Main loop finished?

Yes

No

Fig. 1. Flowchart for the simulator steps. FER is the frame error rate.

Table 2
Simulation parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell radius</td>
<td>850 m</td>
</tr>
<tr>
<td>Number of cells</td>
<td>7</td>
</tr>
<tr>
<td>Chip rate</td>
<td>3.84 Mbps</td>
</tr>
<tr>
<td>Base station antenna</td>
<td>Omni directional</td>
</tr>
<tr>
<td>Standard deviation of shadow fading</td>
<td>8 dB</td>
</tr>
<tr>
<td>Maximum MS transmitted power</td>
<td>21 dBm</td>
</tr>
<tr>
<td>Minimum MS transmitted power</td>
<td>$-50$ dBm</td>
</tr>
<tr>
<td>Uplink thermal noise</td>
<td>$-104$ dBm</td>
</tr>
<tr>
<td>Uplink load threshold (voice only)</td>
<td>0.75</td>
</tr>
<tr>
<td>Uplink load threshold (multimedia traffic)</td>
<td>0.85</td>
</tr>
<tr>
<td>Noise rise target range</td>
<td>4.5–6 dB</td>
</tr>
<tr>
<td>Weight factor (w)</td>
<td>0.5</td>
</tr>
<tr>
<td>Percentage of the offered traffic for classes 1, 2 and 3</td>
<td>0.6, 0.2, 0.2</td>
</tr>
<tr>
<td>Call holding time for classes 1, 2, 3</td>
<td>120 s, 4 min, 4 min</td>
</tr>
</tbody>
</table>
5. Simulation results

Extensive simulations are carried out to compare the performance of the proposed MC-AC algorithm to the conventional SC-AC. We investigate the performance of both algorithms for two types of load distributions: homogenous load and heterogeneous hot around load. In each case, two types of traffic are considered: voice only traffic and a mixed traffic of classes 1, 2 and 3.

5.1. Voice calls in the homogenous load distribution

In this case, voice calls only are considered. The load varies from 10 Erlangs to a load as high as 100 Erlangs per cell. As mentioned earlier, a trade-off is required between the blocking and dropping probabilities which are the most important measures of the system performance. In order to compromise between these probabilities, a study of the effect of the headroom variation is carried out. Figs. 2 and 3 show the blocking and dropping probabilities versus the headroom at two different load values that represent low and high loads at 40 and 100 Erlangs, respectively. From these two figures, we can see that the dropping probability is highly improved, especially at high loads, but the blocking probability remains with small changes. As observed, by choosing noise rise headroom equal to 0.5 dB, we can ensure that the dropping probability is below 3% even at high loads as shown in Fig. 5.

Fig. 2. Effect of headroom variation on the blocking probability for a homogeneous load.

Fig. 3. Effect of headroom variation on the dropping probability for a homogeneous load.
Fig. 4 shows that the MC-AC algorithm is more conservative than the SC-AC in admitting new calls because it checks the noise rise increment due to a new call attempt in all cells to ensure that the noise rise threshold is not violated. However, as shown in Fig. 5, the dropping probability in the case of the MC-AC algorithm is much lower than that in the SC-AC algorithm. An improved performance is obtained because dropping an ongoing connection is much less desirable than blocking a new one. Note also that, although an approximately constant blocking probability difference is obtained in Fig. 4, the dropping probability difference becomes larger for loads higher than 60 Erlangs.

5.2. Multimedia services in the homogenous load case

In this case, a mix of the three classes of traffic is considered as indicated in Table 1. Each class has its required QoS. Figs. 6–9 give a comparison between the performance of the SC-AC and the MC-AC algorithms for this case. Comparing Figs. 6 and 7, we can see an improved performance in terms of the outage probability for each type of traffic. Note that the outage probabilities for class 2 and class 3 traffics are much higher than that for class 1. This is because services with higher bit rates require more transmitted power in order to achieve their target SIR. As the system is power limited, a higher dropping rate than that of the lower bit rate services will occur. At high loads, the dropping probability remains fixed due to much more blocking as shown in Fig. 8, which shows the blocking probability for various services. It can also be seen that services with high bit rates suffer from high blocking probabilities due to their high load requirements. Fig. 9 shows the false accept probability for both algorithms. The false accept probability for the MC-AC algorithm is very small even at high loads. This is due to the estimation errors of the power increment in serving and neighboring cells [6].
Fig. 6. Dropping probability versus the offered traffic for the SC-AC algorithm with homogeneous mixed services.

Fig. 7. Dropping probability versus the offered traffic for the MC-AC algorithm with homogeneous mixed services.

Fig. 8. Blocking probability versus the offered traffic for homogeneous mixed services.
5.3. Voice calls in the hot around load case

In this case, a heterogeneous (hot around) voice only traffic is considered. The load in the central cell is half the load in each of the surrounding cells. We observe from Fig. 10 that the blocking probability in the surrounding cells is the same for both algorithms. In the central cell, the blocking probability using the SC-AC algorithm is higher than that of the MC-AC algorithm as expected. Figs. 11–13 show that the dropping probability is lower in the case of the MC-AC algorithm. Fig. 13 shows that the dropping probability in the central cell in the case of the MC-AC algorithm remains around 1%, even at high loads, whereas it increases rapidly in the case of the SC-AC algorithm. Comparing Figs. 11 and 12, we can see that the overall dropping probability and the dropping probability in the surrounding cells are nearly equal. This is because most of the users in the system are located in the coverage area of the surrounding cells.

5.4. Mixed traffic in the hot around case

This case differs from the previous case in the ability to investigate the impact of high data rate users in the central cell on the neighboring cells, specially those users located near the cell borders. Comparing Figs. 9 and 14, we conclude that the false accept probability is larger in the case of the hot around load distributions. This is because the central cell has a low load. So, admitting a user with the SC-AC algorithm makes the loads in the surrounding cells violate their threshold values with a high probability. As seen from Fig. 14, this probability is approximately zero with the MC-AC algorithm because it checks the status of current load in all cells. To make the SC-AC algorithm behave like the MC-AC algorithm, the load factor threshold of the central cell should be decreased and this will decrease the capacity of the central cell.

![Fig. 9. False accept probability versus the offered traffic for homogeneous mixed services.](image)

![Fig. 10. Blocking probability versus the offered traffic for the hot around case with only class 1 users.](image)
For throughput calculations, and to make a fair comparison, it is necessary to choose the target noise rise $A_{tgt}$ so that the SC-AC and the MC-AC algorithms give the same dropping probability at different loads. Fig. 15 shows that the MC-AC algo-
Fig. 14. False accept probability versus the offered traffic at the central cell with mixed services for the hot around case.

Fig. 15. Total throughput in the central cell versus the offered traffic in the case of mixed services for the hot around scenario.

Fig. 16. Total throughput in the central cell versus the offered traffic in the case of mixed services for the homogeneous case.
6. Conclusions

In this paper, an MC-AC algorithm for WCDMA systems has been proposed. We have developed a simulation model to investigate the performance of the proposed scheme when multimedia services and both homogeneous and heterogeneous load distributions are considered. Simulation results show that the proposed MC-AC algorithm has many advantages over the SC-AC algorithm in terms of the dropping probability, the network stability, and the total system throughput. A trade-off between the dropping and blocking probabilities has been discussed. As dropping an ongoing call is more annoying than blocking a new one, the dropping probability can be lowered without much increase in the blocking probability. We have concluded that a high capacity gain is achieved under heterogeneous (hot around) load distributions. Finally, the results show that high bit rate services suffer from both higher blocking and dropping probabilities. So, it can be said that these services have a limited coverage.

References